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Research Article

Afrogarypus foordi sp. nov. – a new pseudoscorpion species (Pseudoscorpiones, Geogarypidae) from South Africa

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Abstract

A new species of pseudoscorpion, *Afrogarypus foordi* **sp. nov.** (Pseudoscorpiones, Geogarypidae), is described in honour of South African arachnologist Stefan Hendrik Foord. The species is described from both sexes and known from near Fauresmith, Free State, South Africa. It is amongst the smallest species of *Afrogarypus* (chela length ca. 0.6–0.8 mm) and differs from its congeners by lacking trichobothrium *isb* on the fixed chelal finger, monotarsate legs I and II, and details of the galea and dentation of the chelal fingers.

Key words: Afrotropical region, Arachnida, false scorpions, morphology, systematics taxonomy

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Introduction

The pseudoscorpion family Geogarypidae is well represented in the Afrotropical region and comprises the African endemic genus *Afrogarypus* Beier, 1931 (26 recent species) and the cosmopolitan genus *Geogarypus* Chamberlin, 1930 that includes 52 recent species and three fossil species from Baltic amber of Eocene age (Henderickx 2005; WPC 2024). Both genera are common in warm temperate and (sub)tropical regions and the South African fauna is quite diverse with 12 valid species of *Afrogarypus* and nine species of *Geogarypus* (WPC 2024). These species have been recorded from all biomes of the country, including arid Karoo landscapes in the northwest, although they are most common along the mesic coastal sides of the country's mountains. The family has also seen recent taxonomic work and a detailed and illustrated revision of the South African fauna is available (Neethling and Haddad 2016). An updated identification key and descriptions of three new species have also been published recently (Neethling 2024).

Geogarypids are four-eyed and rather flat pseudoscorpions that vary in size between a few millimetres to almost a centimetre (Neethling 2024). They are usually collected from leaf litter habitats, although they can also be found under rocks and decaying tree bark (Nassirkhani 2014; Battirola et al. 2017). In South Africa, these pseudoscorpions can be locally abundant in leaf litter hab-

itats of indigenous or undisturbed forests and are probably amongst the most common pseudoscorpions in South Africa.

The present paper documents and names an additional species of *Afrogarypus* that we name in honour of South African arachnologist Stefan Henrik Foord. This new species is amongst the smallest of the genus (body length ♀ 1.38–1.54 mm, ♂ 1.17–1.26 mm) and known from Bankfontein Farm near Fauresmith, Free State in the grassland biome of South Africa. It is described from both sexes and diagnosed against all other species of *Afrogarypus* in the country. The species represents an interesting case of trichobothria reduction since trichobothrium *isb* on the fixed chelal finger is absent. Such reductions might result from neoteny and the loss of *isb* occurs independently in several pseudoscorpion genera that belong to the families Garypidae (e.g. *Synsphyronus* Chamberlin, 1930), Garypinidae (e.g. *Solinellus* Muchmore, 1979), Geogarypidae (*Geogarypus*), Neobisiidae (*Microbisium* Chamberlin, 1930), Sternophoridae (*Afrosternophorus* Beier, 1967) and Syarninidae (*Microblothrus* Mahnert, 1985; also see Harvey 2023 for a review on this topic). *Afrogarypus foordi* sp. nov. also shows tarsal reduction in legs I and II that are monotarsate and not divided like in most other species. Tarsal reduction is less common in pseudoscorpions than the reduction of trichobothria but has been recorded in the families Garypidae (e.g. *Synsphyronus* in Australia; Cullen and Harvey 2021) and Geogarypidae (see below or Neethling and Haddad 2016). Both reductive features (trichobothria and leg tarsi) are recorded here for the second time in the South African geogarypid fauna.

Materials and methods

Specimen origin

The specimens were obtained from the Arachnology wet collection of the Terrestrial Invertebrates department of the National Museum in Bloemfontein, South Africa (NMBA). While working through, and updating, the pseudoscorpion collection, the first author noted a number of Geogarypidae specimens originally identified as *Afrogarypus subimpressus* (Beier, 1955) from three sites located in the interior of the country. Given that the type locality of the species is at Cape Point Nature Reserve in the Western Cape, the specimens were re-examined and found to belong to a novel *Afrogarypus* species. All specimens were deposited back in the Arachnology wet collection of the National Museum Bloemfontein, South Africa, after identifications and descriptions were made, with NMBAP being the accession sequence for pseudoscorpions.

Morphological analysis

The specimens were sorted, identified and sexed using a Novel NSZ-606 stereomicroscope. Lactic acid clearing followed the same method as in Neethling and Haddad (2016). Specimens were cleared in 90% lactic acid with the desired structures (the chelicerae, pedipalps, leg I and leg IV) dissected afterwards under a stereomicroscope, using fine pins (Hu and Zhang 2012). Dissected parts were kept in microvials and stored with the rest of the specimens. These were then individually mounted on standard microscope slides, with small pieces of nylon fishing line used to elevate a standard slip above the structures (Harvey

2010). The slides were examined with a Nikon Eclipse 50i Binocular microscope fitted with a Nikon Digital Sight DS-U3 system equipped with a Nikon DS-Fi1 5 Megapixel camera. High resolution digital photographs, as well as digital measurements, were made using NIS Elements Imaging Software 64-bit v.3.22.00 (Build 710) 2010. Adobe Photoshop CS5 Extended 64-bit v.12.0 2010 (Adobe Inc.) was used to create extended focal range images of the studied structures via stacking of the digital photographs. These images were then traced to produce line drawings. Distribution maps were generated using the software program Quantum GIS Hannover version 3.16 (QGIS Development Team 2020).

Terminology mostly follows Harvey (1992) except for the chelicerae, which follows Judson (2007). Ratios are given as Length / Width or Depth for legs I and IV. Chaetotaxy, obtained from cleared specimens, given as ♀(♂).

The following abbreviations are used in the figures and text:

Chela trichobothria

b	basal
sb	sub-basal
st	sub-terminal
t	terminal
ib	interior basal
isb	interior sub-basal
ist	interior sub-terminal
it	interior terminal
eb	exterior basal
esb	exterior sub-basal
est	exterior sub-terminal
et	exterior terminal

Chelicera setae

es	exterior seta
bs	basal seta
sbs	sub-basal seta
is	interior seta
ls	laminal seta
gs	galeal seta

Taxonomy

Family Geogarypidae Chamberlin, 1930

Genus *Afrogarypus* Beier, 1931

Afrogarypus: Beier 1931: 317 (original description); Harvey 1986: 758; Harvey 1991: 249; Neethling and Haddad 2016: 7–9.
Geogarypus (*Afrogarypus*): Beier 1932: 236; Beier 1955: 301; Heurtault 1970: 1365.

Type species. *Garypus senegalensis* Balzan, 1892, by original designation.

Afrogarypus foordi sp. nov.

https://zoobank.org/5B894EA4-88E9-401C-9A0F-761BB6392F84
Figs 1–4

Type materials. ***Holotype*** • 1♀, South Africa, Free State, Fauresmith, Bankfontein Farm, 30°04'S, 24°53'E, 1192 m a.s.l., Hillside Shrubs, Leaf litter sifting, leg. University of the Free State Entomology Students, 04.IV.2015 (NMBAP 00279).

Paratype • 1♂, Same data as holotype (NMBAP 00466).

Other material examined. South Africa: Free State • 1♂, Bethulie, Tussen die Riviere Nature Reserve, 30°30'S, 26°07'E, 1286 m a.s.l., Shrubs against Rocky Hill in Veld, Leaf litter sifting, leg. L. Lotz & C.R. Haddad, 16.X.2008 (NMBAP 00135) • 2♀, Fauresmith, Bankfontein Farm, 30°04'S, 24°53'E, 1187 m a.s.l., Tree Grove in Veld, Leaf litter sifting, leg. University of the Free State Entomology Students, 02.IV.2015 (NMBAP 00237); Western Cape • 1♀, 3♂, Beaufort West, Karoo National Park, Klipspringer Pass, 32°19'S, 22°27'E, 1126 m a.s.l., Karoo Shrubs, Leaf litter sifting, leg. J.A. Neethling, 14.XI.2012 (NMBAP 00175).

Etymology. The species is named in remembrance of Professor Stefan Hendrik Foord, our friend and colleague, for his contributions to Arachnology, and for his outstanding contributions to the biodiversity and ecology of South African spiders.

Diagnosis. Small species (chela length ♀ 0.71–0.79 mm, ♂ 0.58–0.63 mm), with a wide depression located dorsally, before the fixed finger, on the chelae of both females and males; cheliceral hand with five acuminate setae; female galea with seven rami, male galea simple and with no rami; rallum present as a simple single blade. Differs from *Afrogarypus carmenae* Neethling & Haddad, 2016, *A. excelsus* (Beier, 1964), *A. haddadi* Neethling, 2024, *A. impressus* (Tullgren, 1907b), *A. megamolaris* Neethling & Haddad, 2016, *A. minutus* (Tullgren, 1907a), *A. pseudotriangularis* Neethling, 2024, *A. purcelli* (Ellingsen, 1912), *A. robustus* (Beier, 1947), *A. subimpressus* (Beier, 1955) and *A. triangularis* (Ellingsen, 1912) by both lacking trichobothrium ***isb*** on the fixed chelal finger, as well as having monotarsate legs I and II. Differs from *Afrogarypus castigatus* Neethling & Haddad, 2016, by having seven rami, arranged in an arc across the tip, on the female galea, as opposed to nine arranged in two groups, one on each side of the galea; having a broad, well developed sulcus on the dorsal surface of the chela, as opposed a wide, shallow concave region; having a chelal movable finger the same length to longer than the chelal hand (chelal movable finger ♀ 1.00–1.13, ♂ 1.03–1.23 times longer than chelal hand without pedicel), as opposed to a chelal movable finger shorter than the chelal hand (chelal movable finger ♀ 0.68–0.78, ♂ 0.69–0.75 times longer than chelal hand without pedicel); having the granulated texture of the chelal hand terminate above trichobothrium ***esb***, as opposed to having a pronounced granulated ridge terminating between ***est*** and ***ist*** and spanning approximately along half the total fixed finger length; having trichobothrium ***it*** directly above ***et***, as opposed to ***it*** situated further back, between ***et*** and ***t***, and trichobothrium ***t*** situated equidistant between ***ist*** and ***et***, as opposed to ***t*** being close to ***ist***.

Description. *Carapace*: Strongly sub-triangular, narrow furrow posterior to the eyes (Figs 1A, C, 3H). Heavily constricted anteriorly into a cucullus, constriction beginning at the medial furrow. Two pairs of corneate eyes situated on ocular tubercles, located about one-third away from the anterior edge. Uniformly granular in texture, dark brown from cucullus to furrow, with a slightly lighter posterior edge in both sexes. Four prominent acuminate setae located on anterior edge, row of acuminate setae (♀ 9–11 ♂ 8–9) seated within rims, located on the posterior margin. Numerous small acuminate setae present on carapace.

***Abdomen*:** Wider than carapace and subovate. Tergites granular in texture in both sexes, retaining mostly the same coloration as the posterior edge of the carapace. Tergites I and II each with a faint darker median spot, as well as a faint

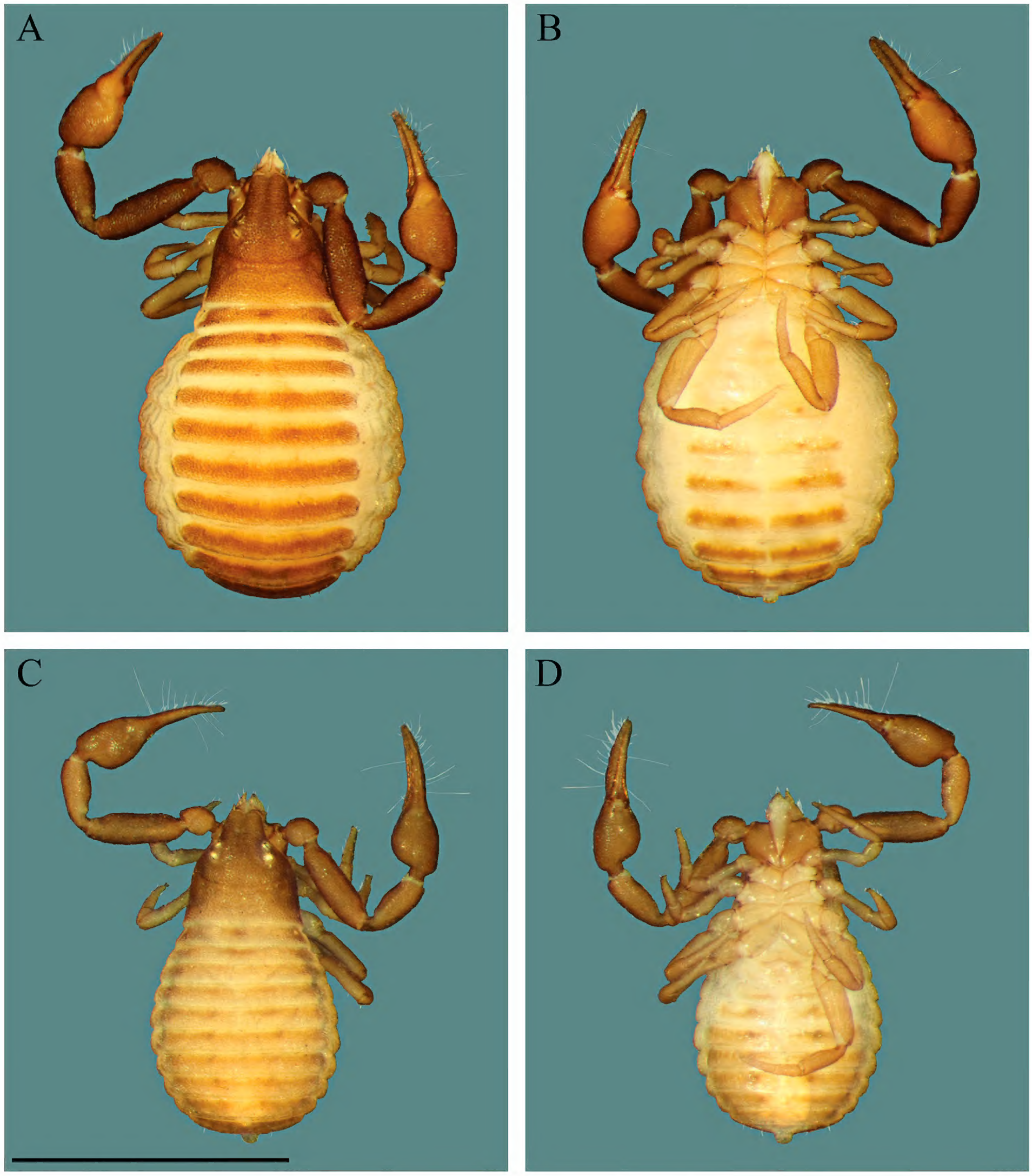

Figure 1. Digital microscope photographs of *Afrogarypus foordi* sp. nov., female holotype (**A, B**) and male paratype (**C, D**) **A, C** dorsal view **B, D** ventral view. Scale bar: 1.00 mm.

darker spot at each edge of the tergite. Tergite I–VIII uniform in colour, tergites IX–XI darker brown, tergite XII uniformly lighter in colour (Fig. 1A, C). Tergal setae acuminate and located on the posterior of each tergite. Sternite XII same colour as tergite XII in both sexes. In female, sternites range in colour from tan in sternites II–IV to light brown in sternites V–XI, becoming darker from sternite V to XI. Central tan-coloured region present on sternites V–X, giving these sternites a divided appearance. Sternites V–IX with paired faint darker spots. Male

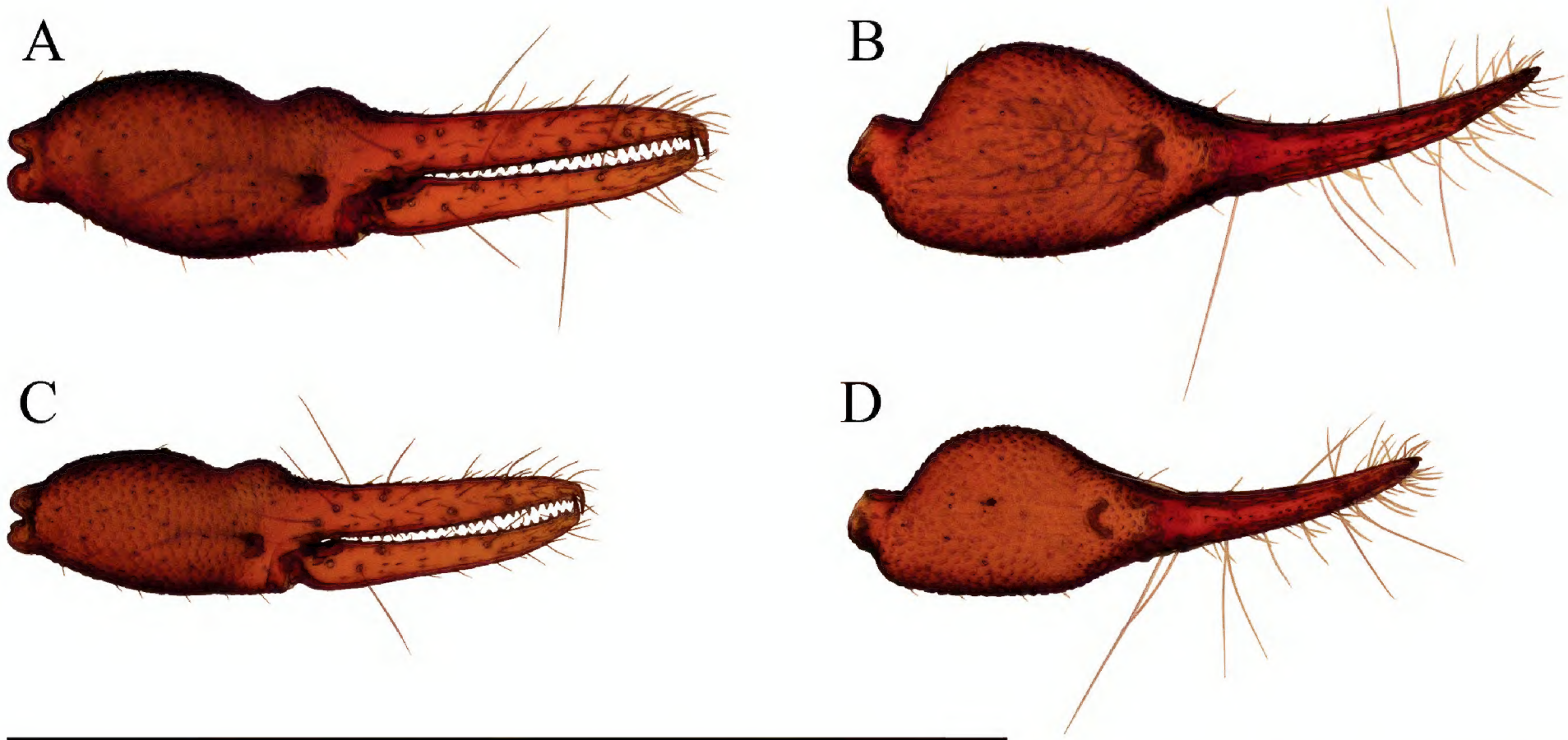

Figure 2. Digital microscope photographs of non-type (NMBAP 00175) *Afrogarypus foordi* sp. nov. right chela: female (**A, B**) and male (**C, D**) **A, C** retrolateral view **B, D** dorsal view. Scale bar: 1.00 mm.

sternites II–III tan colour, sternites IV–XI light brown, becoming darker from sternite IV to XI. Central tan-coloured region present on sternites IV–IX, giving these sternites a divided appearance. Sternites V–IX with paired faint darker spots (Fig. 1B, D). Female operculum with 11 acuminate setae on the anterior genital plate, separated into five setae distributed along the posterior margin of the genital plate, and two groups of three setae each situated just anterior of the posterior row, separated by two prominent lyriform fissures, near the centre. Male operculum with ten acuminate setae on the anterior genital plate, separated into seven setae distributed along the posterior margin of the genital plate, and three setae anterior to these. Two prominent lyriform fissures present centrally, just anterior to the posterior setae row. Male sternite III with 15 acuminate setae, separated into four setae located along the anterior margin of the sternite, at the edge of the genital opening, three setae located centrally behind these and eight setae distributed along the posterior margin of the sternite. Pleural membrane wrinkled-plicate, cream in both sexes. Lateral sclerites absent in both sexes.

Tergal chaetotaxy: 8(8): 12(9): 10(10): 10(9): 12(10): 9(9): 8(10): 8(9): 7(8): 6(7): 6(8): 2(2).

Sternal chaetotaxy: ?(?): 11(9): 8(15): 11(11): 16(13): 13(14): 14(12): 11(10): 7(7): 6(6): 4(4): 2(2).

***Pedipalp*:** In both sexes all segments granular in texture with small acuminate setae scattered over the surface, except the pedicels. Trochanter, femur and patella dark brown in colour, female chela somewhat lighter, male chela same colour as preceding palp segments. Trochanter rounded in shape, distinct apophysis present ventrally. Femur ratios overlap considerably in females and males, 3.07–3.43 (♀) to 2.92–3.33 (♂) times longer than wide. Femur constricted at pedicel, widening quickly to form base, then widening slightly before constricting again at end. Patella constricted and distinctly angled at pedicel, widening markedly into a cone, 2.43–2.77 (♀) to 2.33–2.73 (♂) times longer than wide. Several small lyriform fissures present on a bulge on the dorsal surface, just distal of base. Disto-prolateral excavation present (Fig. 3B).

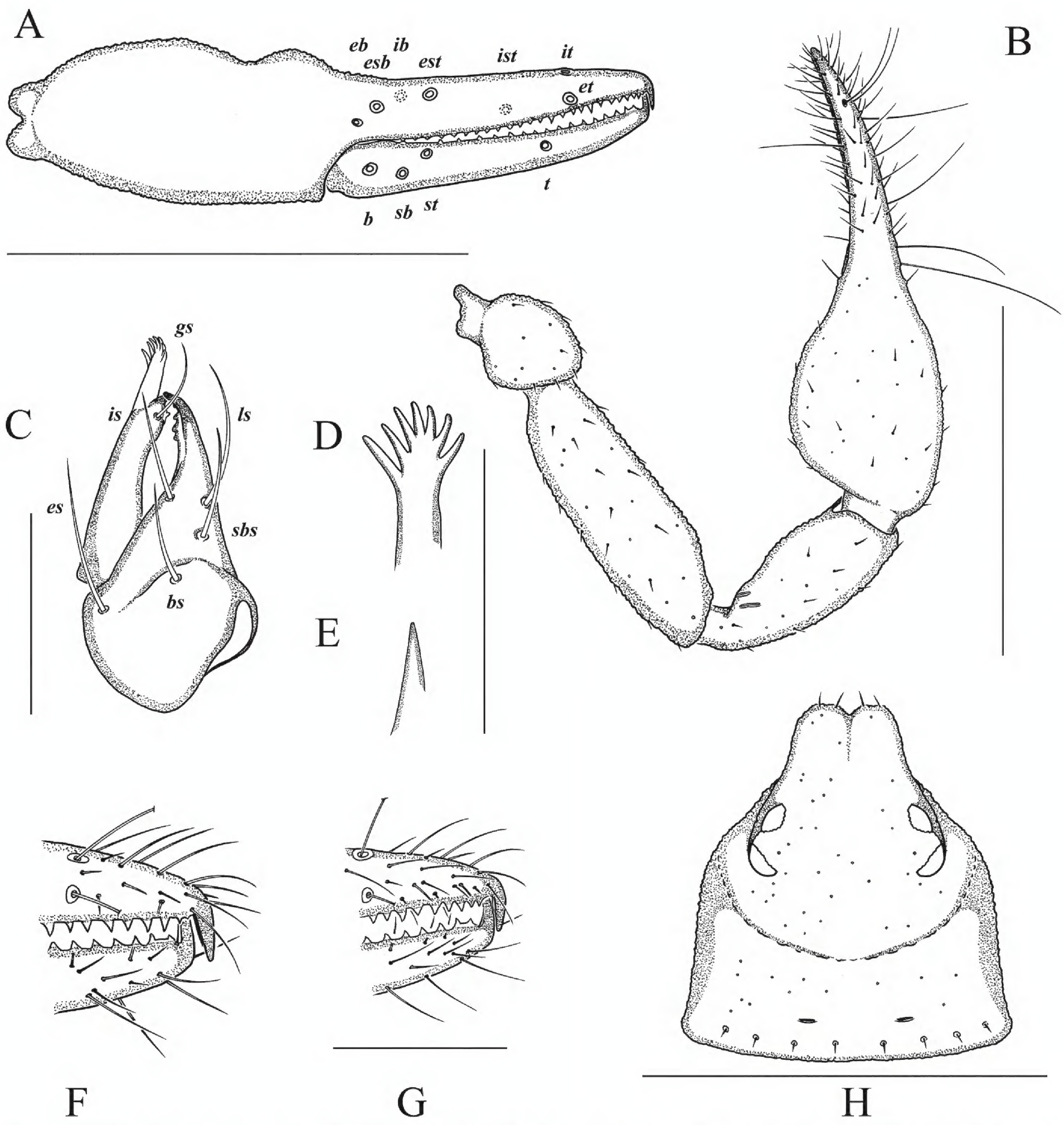

Figure 3. *Afrogarypus foordi* sp. nov. (NMBAP 00175) **A** female right chela, retrolateral view **B** female right pedipalp, dorsal view **C** female left chelicera, dorsal view **D** female galea **E** male galea **F** female chelal fingers, anterior retrolateral view **G** male chelal fingers, anterior retrolateral view **H** female carapace, dorsal view. Scale bars: 0.50 mm (**A, B, H**); 0.10 mm (**C, F, G**); 0.05 mm (**D, E**).

Chela*:** Uniformly brown in both sexes. Hand granular in texture up to base of movable finger, granular texture terminating above trichobothrium ***esb in both sexes. Broad, well-developed sulcus present on dorsal surface, located just proximal to the base of the fixed finger. Dorsal bulge located just anterior of sulcus. Female sulcus marginally deeper, male sulcus shallower (Fig. 2A, C). Hand of both sexes strongly convex on the prolateral edge, much less so on the retrolateral edge (Fig. 2B, D). Male chelae smaller. Both sexes with a short pedicel (pedicel 0.13–0.14 ♀ 0.14–0.16 ♂ times longer than chelal hand) and

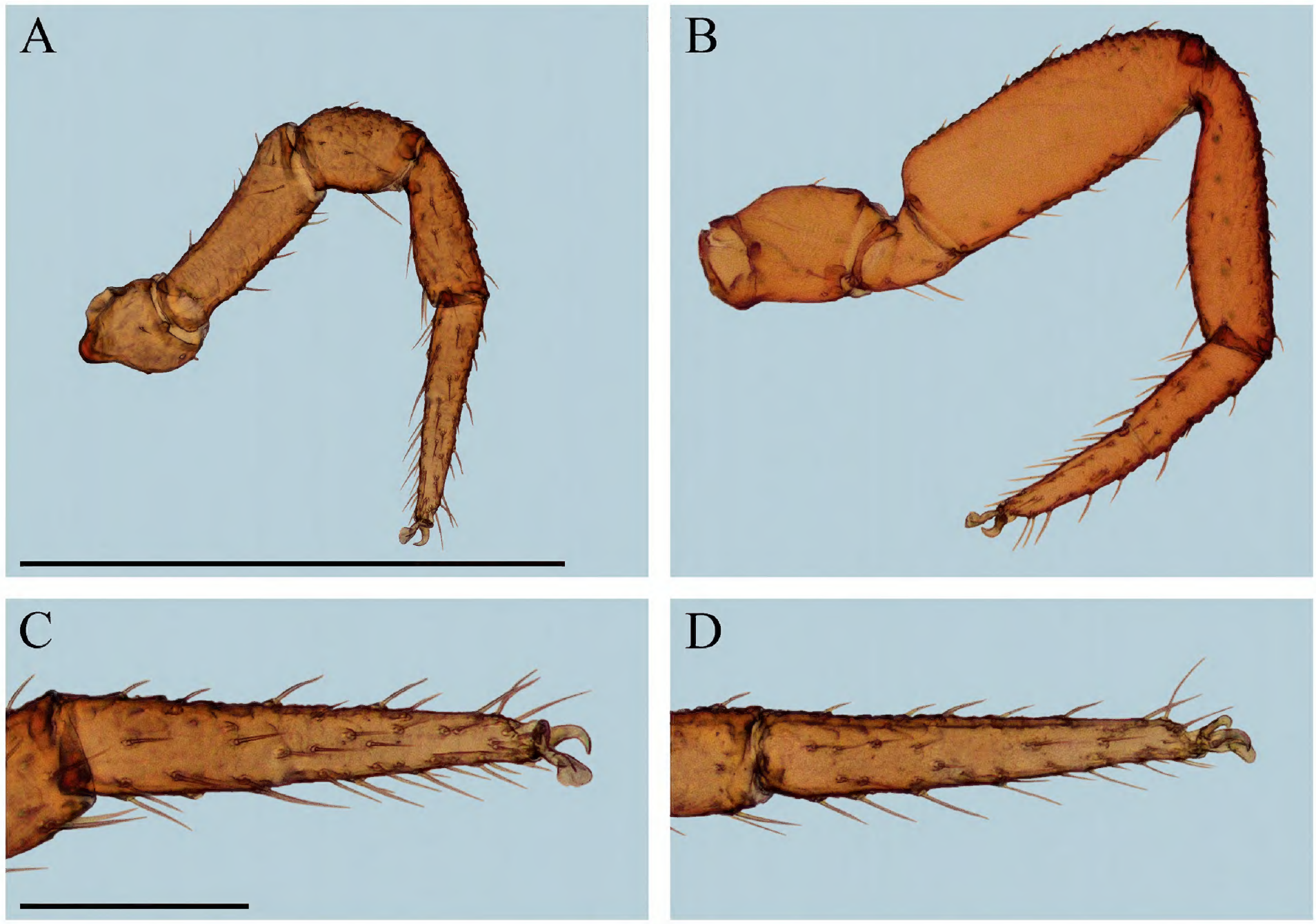

Figure 4. Digital microscope photographs of non-type (NMBAP 00175) *Afrogarypus foordi* sp. nov. leg morphology: female (**A, B, C**) and male (**D**) **A** monotarsate leg I, lateral view **B** diplotarsate leg IV, lateral view **C** female fused tarsal segments of leg I **D** male fused tarsal segments of leg I. Scale bars: 0.50 mm (**A, B**); 0.10 mm (**C, D**).

a prolaterally slanted posterior hand edge. Fingers narrow and curved slightly prolaterally, as long to slightly longer than chelal hand in both sexes. Venom apparatus present on both fingers. Fixed and movable chelal fingers with seven and four trichobothria respectively as in fig. 3A. Trichobothrium ***isb*** absent in both sexes.

Chelal teeth strongly sclerotized, acute and retrorse in both sexes. Female fixed finger with 23–25 teeth. First two teeth behind venom apparatus distinctly smaller than the proceeding teeth (Fig. 3F), rest of the teeth spaced equidistant from each other along the fixed chelal finger, reducing in size proximally, still acute. Female movable finger with 17–19 teeth. First two teeth behind venom apparatus distinctly smaller and situated on a raised ridge. Rest of the teeth larger, both reducing in size proximally, as well as becoming spaced further apart. Male fixed finger with 24–25 teeth. First two teeth just behind venom apparatus distinctly smaller and spaced closer together than the proceeding teeth (Fig. 3G). Rest of the teeth spaced equidistant from each other along the fixed chelal finger, reducing in size proximally, still acute. Male movable finger with 18–19 teeth. First two teeth behind venom apparatus distinctly smaller and situated on a raised ridge. Rest of the teeth larger, both reducing in size proximally, as well as becoming spaced further apart.

***Chelicera*:** Hand with five long and acuminate setae (Fig. 3C). Fixed finger of both sexes with four to five teeth. Female movable finger with one to two very

small teeth, male movable finger without any discernible teeth. Galea complex, with seven rami (♀) (Fig. 3D), simple with no rami (♂) (Fig. 3E). Rallum with a single blade in both sexes. Serrula exterior with 16–17 lamellae (♀), 15–16 lamellae (♂). Lamina exterior present in both sexes.

***Coxae and legs*:** Pedipalpal coxae same colour to slightly lighter than rest of pedipalps. Coxae I–IV tan to light brown. Legs I–IV light brown in colour. Legs I and II monotarsate (Figs. 4A, C, D), legs III and IV diplotarsate (Fig. 4B). All legs with simple claws; arolium longer than claws.

Measurements (mm): Body length ♀ 1.38–1.54 ♂ 1.17–1.26; Carapace ♀ 0.48–0.52 × 0.46–0.49 (0.98–1.13) ♂ 0.46–0.49 × 0.41–0.43 (1.07–1.20); Chelicera ♀ 0.16–0.18 × 0.09–0.11 (1.45–2.00) ♂ 0.13–0.14 × 0.07–0.08 (1.63–2.00), movable finger length ♀ 0.10–0.11 ♂ 0.07–0.08; Pedipalps: femur ♀ 0.46–0.48 × 0.14–0.15 (3.07–3.43) ♂ 0.38–0.40 × 0.12–0.13 (2.92–3.33), patella ♀ 0.34–0.36 × 0.13–0.14 (2.43–2.77) ♂ 0.28–0.30 × 0.11–0.12 (2.33–2.73), chela ♀ 0.71–0.79 × 0.22–0.25 (2.84–3.59) ♂ 0.58–0.63 × 0.17–0.19 (3.05–3.71), hand ♀ 0.32–0.34 × 0.22–0.25 (1.28–1.55) ♂ 0.26–0.29 × 0.17–0.19 (1.37–1.71), movable finger length ♀ 0.34–0.36 ♂ 0.30–0.32; Leg I: femur ♀ 0.21–0.22 × 0.08–0.09 (2.33–2.75) ♂ 0.17–0.18 × 0.07 (2.43–2.57), patella ♀ 0.11–0.12 × 0.08–0.09 (1.22–1.50) ♂ 0.10–0.11 × 0.06 (1.67–1.83), tibia ♀ 0.15–0.17 × 0.06–0.07 (2.14–2.83) ♂ 0.13–0.15 × 0.05–0.06 (2.17–3.00), metatarsus–tarsus ♀ 0.22–0.23 × 0.05 (4.40–4.60) ♂ 0.19–0.20 × 0.04 (4.75–5.00); Leg IV: femoropatella ♀ 0.40–0.44 × 0.12–0.13 (3.08–3.67) ♂ 0.32–0.33 × 0.10–0.11 (2.91–3.30), tibia ♀ 0.29–0.32 × 0.08–0.09 (3.22–4.00) ♂ 0.24–0.26 × 0.06–0.07 (3.43–4.33), metatarsus ♀ 0.14–0.16 × 0.05 (2.80–3.20) ♂ 0.12–0.13 × 0.05 (2.40–2.60), tarsus ♀ 0.14–0.15 × 0.04 (3.50–3.75) ♂ 0.12–0.13 × 0.03 (4.00–4.33).

Remarks. *Afrogarypus foordi* sp. nov. represents the second geogarypid species in South Africa that both exhibits the absence of trichobothrium ***isb*** on the fixed chelal finger, as well as monotarsate legs I and II. With the discovery of this species, a correction has to be made to the distribution data presented in Neethling and Haddad (2016), since the specimens identified in this study were erroneously identified, and presented as *Afrogarypus subimpressus* in the 2016 study. Thus, the distribution of *Afrogarypus subimpressus* no longer has any inland specimens, with the remaining distributions being along the coast of the Western Cape Province.

Please also note in this context that these two species are not the only geogarypid species with reductive features. Other geogarypids outside of South Africa are also known to have seven trichobothria on the fixed chelal finger and these include *Geogarypus conatus* Harvey, 1986 from Australia, and the Neotropical species *G. bucculentus* Beier, 1955 and *G. pustulatus* Beier, 1959 (Harvey, 1987).

Ecology. *Afrogarypus foordi* sp. nov. is currently known to inhabit the shaded leaf litter found under indigenous shrub and tree stands in the veld of the Free State, as well as those of larger Karoo bushes. Its known distribution (Fig. 5) falls outside of both the Maputaland-Pondoland-Albany hotspot, as well as the Cape Floristic Region, where the majority of South Africa's Geogarypidae diversity is found (Neethling and Haddad 2016; Neethling 2024). In contrast to the arboreal lifestyle of *Afrogarypus castigatus*, the other South African geogarypid that exhibits the absence of trichobothrium ***isb*** and monotarsate

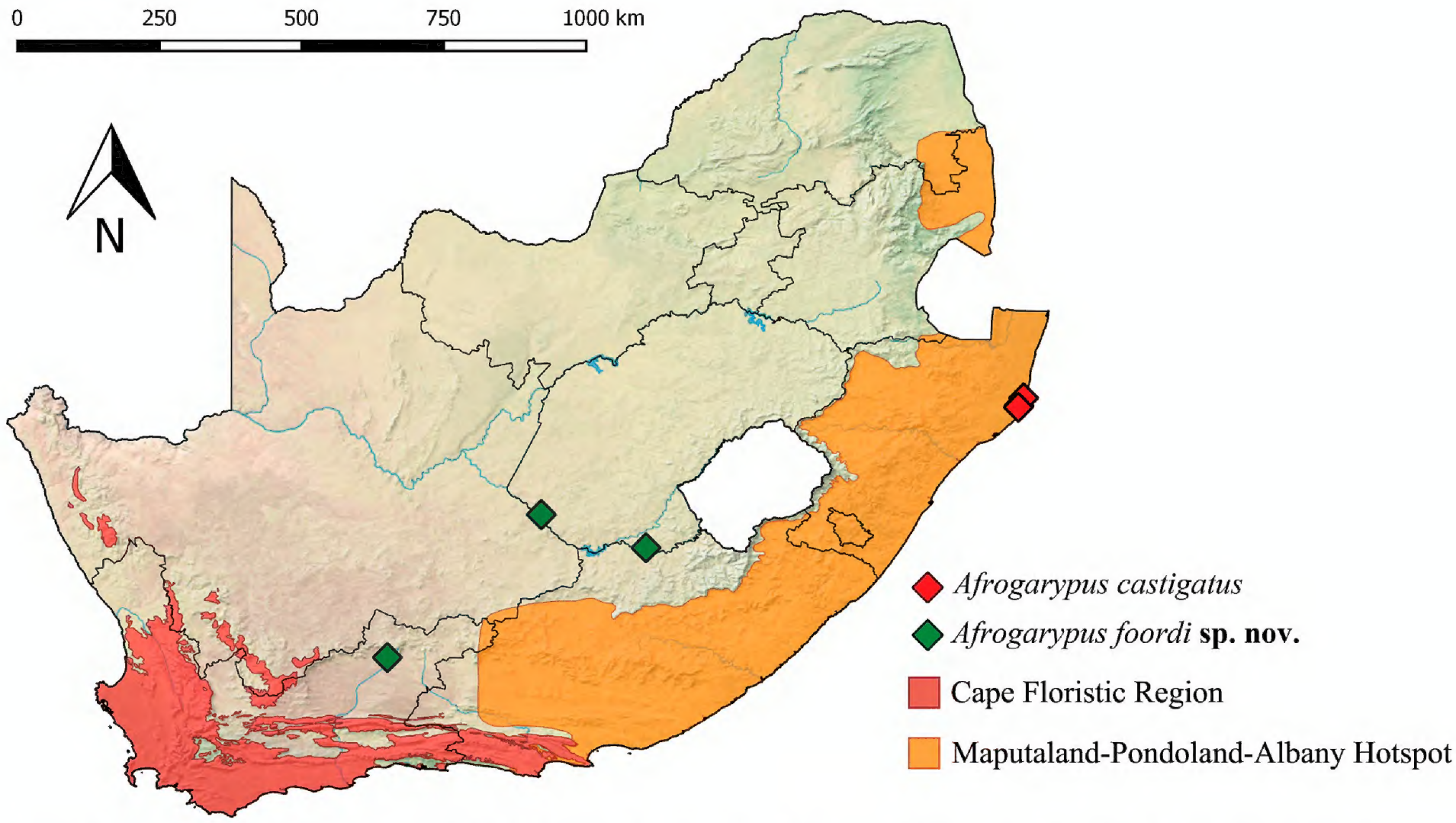

Figure 5. Topographical map of South Africa displaying the distribution of *Afrogarypus foordi* sp. nov., as well as the morphologically similar *A. castigatus* Neethling & Haddad, 2016. Also highlighted are the distributions of the Cape Floristic Region and the Maputaland-Pondoland-Albany hotspots. Shapefile acquired from http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_main.aspx (accessed 20.XI.2020).

legs I and II, all specimens of *A. foordi* sp. nov. have been found in leaf litter. *Afrogarypus castigatus* furthermore possess much more compact bodies with comparatively shorter, more stout appendages, while *A. foordi* sp. nov. exhibits body proportions that are much less compact and more reminiscent of other ground-dwelling Geogarypidae. Specimens were collected during the months of April, October and November. Elevation: 1187–1286 m.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

All authors have contributed equally.

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Data availability

All of the data that support the findings of this study are available in the main text.

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